

We claim:

1 1. A temperature compensated apparatus for filtering light comprising:  
2 a holographically recorded grating defined in a photosensitive layer for  
3 providing optical filtration for light incident on the grating with a predetermined  
4 angle of incidence; and  
5 angulation means responsive to temperature for tilting relative to the angle  
6 of incidence of the light with respect to the grating as a function of temperature of  
7 the grating so that changes in the filtration by the grating compensate for  
8 changes in temperature of the grating to maintain effective filtration of the light  
9 approximately constant.

1 2. The apparatus of claim 1 where the angulation means comprises a  
2 bimetallic strip having a differential thermal expansion coefficient and wherein  
3 light is reflected from or by means of the strip at the predetermined angle of  
4 incidence, the differential thermal expansion coefficient of the strip being selected  
5 to vary the curvature of the strip and hence the angle of incidence of the light by  
6 a degree approximately corresponding to the shift in filtration response of the  
7 grating as a function of temperature so that Bragg filtration provided by the  
8 grating is approximately independent of temperature of the grating.

1 3. The apparatus of claim 2 where the bimetallic strip is comprised of a  
2 aluminum and silicon composite.

1 4. The apparatus of claim 1 where the grating is characterized by a Bragg  
2 wavelength,  $2n \Lambda \cos \theta_{in} = \lambda_B(T)$  where  $n$  is the index of refraction of the bulk  
3 material of the layer,  $\Lambda$  is the period of the grating,  $\theta_{in}$  is the internal angle of the  
4 incident light within the layer and  $\lambda_B(T)$  is the Bragg wavelength as a function of  
5 temperature of the grating,  $T$ , the angulation means changing  $\theta_{in}$  of the light to  
6 approximately match the change in Bragg wavelength  $\lambda_B(T)$  for a change in  
7 temperature,  $\Delta T$ .

1 5. The apparatus of claim 4 where the Bragg wavelength  $\lambda_B(T)$  is determined  
2 by a 0.5 dB criterion.

1 6. The apparatus of claim 1 where the angulation means changes the angle  
2 of incidence of the light according to

3 
$$\frac{\cos(\theta_B + \Delta\theta)}{\cos \theta_B} = \frac{1}{(1+a\Delta T)(1+b\Delta T)}$$

4 where  $\Delta T$  is the change in temperature of the grating, where  $a$  is the thermal  
5 expansion coefficient of the layer, where  $b$  is the thermal coefficient of the  
6 dielectric constant and hence the index of refraction of the layer, where  $\theta_B$  is the  
7 Bragg angle corresponding to a target wavelength for filtration when  $\Delta T = 0$ , and

8 where  $\Delta\theta_B$  is the change in the Bragg angle made to compensate to the  
9 temperature change  $\Delta T$ .

1 7. A method for temperature compensating a Bragg filter comprising:  
2 providing a holographically recorded grating defined in a photosensitive  
3 layer for providing optical filtration;  
4 directing light incident on the grating at a predetermined angle of  
5 incidence; and  
6 controlling the angle of incidence of the light relative to the grating in  
7 response to temperature changes in the grating so that filtration by the grating  
8 compensates for changes in temperature of the grating to keep effective filtration  
9 approximately constant.

1 8. The method of claim 7 where controlling the angle of incidence of the light  
2 relative to the grating comprises:  
3 reflecting the light from a bimetallic strip having a differential thermal  
4 expansion coefficient onto the grating; and  
5 varying the curvature of the strip and hence the angle of incidence of the  
6 light onto the grating to the shift the Bragg filtration of the grating according to the  
7 change in temperature so that effective filtration provided by the grating is  
8 approximately independent of temperature of the grating.

1 9. The method of claim 8 where reflecting the light from a bimetallic strip  
2 reflects the light from a strip comprised of a aluminum and silicon composite.

1 10. The method of claim 7 where the grating is characterized by a Bragg  
2 wavelength,  $2n \Lambda \cos \theta_{in} = \lambda_B(T)$  where n is the index of refraction of the bulk  
3 material of the layer,  $\Lambda$  is the period of the grating,  $\theta_{in}$  is the internal angle of the  
4 incident light within the layer and  $\lambda_B(T)$  is the Bragg wavelength as a function of  
5 temperature of the grating, T, and where controlling the angle of incidence of the  
6 light relative to the grating changes  $\theta_{in}$  of the light to approximately match the  
7 change in Bragg wavelength  $\lambda_B(T)$  for a change in temperature,  $\Delta T$ .

1 11. The method of claim 10 further comprising determining the Bragg  
2 wavelength  $\lambda_B(T)$  by a 0.5 dB criterion.

1 12. The method of claim 7 where controlling the angle of incidence of the light  
2 relative to the grating changes the angle of incidence of the light according to

3 
$$\frac{\cos(\theta_B + \Delta\theta)}{\cos \theta_B} = \frac{1}{(1 + a\Delta T)(1 + b\Delta T)}$$

4 where  $\Delta T$  is the change in temperature of the grating, where a is the thermal  
5 expansion coefficient of the layer, where b is the thermal coefficient of the  
6 dielectric constant and hence the index of refraction of the layer, where  $\theta_B$  is the  
7 Bragg angle corresponding to a target wavelength for filtration when  $\Delta T = 0$ , and

8 where  $\Delta\theta_B$  is the change in the Bragg angle made to compensate to the  
9 temperature change  $\Delta T$ .

1 13. A temperature compensated apparatus for filtering light comprising:  
2 a holographic filter defined in a photosensitive layer of iron doped  $\text{LiNbO}_3$   
3 for providing optical filtration for light incident with a predetermined angle of  
4 incidence at a Bragg wavelength defined at the middle of a bandwidth of  
5 transmittance through the filter; and  
6 angulation means responsive to temperature for tilting the relative angle of  
7 incidence of the light as a function of temperature with respect to the filter so that  
8 changes in the filtration compensate for changes in temperature of the filter to  
9 maintain effective filtration approximately constant.

1 14. The apparatus of claim 13 where the angulation means comprises a mirror  
2 coupled to a bimetallic composite strip.

1 15. The apparatus of claim 14 where the mirror comprises a MEMS mirror.

1 16. The apparatus of claim 15 where the MEMS mirror is comprised of a mirror  
2 portion including a gold film deposited on silicon and a beam of aluminum  
3 deposited on silicon which deflects as temperature varies.

1 17. The apparatus of claim 15 further comprising a second MEMs mirror  
2 optically coupled to the filter to correct for walk-off to allow coupling with an optic  
3 fiber.

1 18. The apparatus of claim 13 where the angulation means is annealed to  
2 reduce hysteresis.

1 19. The apparatus of claim 1 where the angulation means is annealed to reduce  
2 hysteresis.

1 20. The apparatus of claim 1 where the angulation means and the grating are  
2 thermally coupled to each.